Journal of Air Transport Management 40 (2014) 192–206

Contents lists available at ScienceDirect

Journal of Air Transport Management

journal homepage: www.elsevier.com/locate/jairtraman

A model to forecast airport-level General Aviation demand

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ARTICLE INFO

Article history:
Available online 2 August 2014

Keywords:
General Aviation
Airport-level GA demand forecast
Itinerant operations
Local operations
Relative fuel price
Impact of fuel price

ABSTRACT

General Aviation (GA) demand forecast plays an important role in aviation management, planning and policy making. The objective of this paper is to develop an airport-level GA demand forecast model. The GA demand at an airport is modeled as a function of social-economic and demographic factors, the availability of supply factors, the competition from the commercial aviation, the number of based aircraft, and the presence of a flight school. Our models suggest that the relative fuel price – fuel price compared with personal income – is a significant determinant of airport level GA demand. The elasticity of itinerant and local GA demand with respect to the relative fuel price is −0.43 and −0.52, respectively. Our results are compared with those reported in other studies. Furthermore, we made projections of GA demand for the airports in the Terminal Area Forecast (TAF) using three fuel price scenarios from the Energy Information Administration. Our projections under the "business-as-usual" fuel price scenario are close to those in the TAF. Our models could prove useful, for example, for the Federal Aviation Administration and airport planners to prepare airport-level GA demand forecast.

1. Introduction

General Aviation (GA) is the operation of civilian aircraft for purposes other than commercial passenger or cargo transport. In the literature, a significant amount of effort has been devoted to forecasting GA demand. This paper is intended as a contribution to this topic. GA demand forecast plays an important role in aviation management, planning and policy making. For example, the forecast of GA activities is one factor used by the Federal Aviation Administration (FAA) to conduct benefit-cost analyses associated with airport development (GRA, 2011), and decide the allocation of construction/improvement grants among airports (Ghobrial, 1997), the size of air traffic controller workforce, and the provision of navigation and communication services. GA demand forecast serves as a fundamental component in evaluating the new concepts and technologies suggested to the National Aeronautics and Space Administration (NASA) to meet the national requirement for an improved air traffic management system (Wingrove et al., 2002). Forecasts of GA demand are also utilized by many local governments and airport planners to support operational planning and personnel requirements, make investment decisions related to the development of an airport and the community around it, and evaluate the need for additional aviation facilities.

1.1. Objective of this study

The objective of this paper is to develop an airport-level GA demand forecast model. In this study, airport-level GA demand refers to the number of GA operations (including both takeoffs and landings) at an airport. GA operations are classified into two types: local operations and itinerant operations. Local operations refer to aircraft operating in the traffic pattern or within sight of the tower, or aircraft known to be departing or arriving from flight in local practice areas, or aircraft executing practice instrument approaches at the airport. Itinerant operations refer to operations of aircraft going from one airport to another. The FAA reports all aircraft operations other than local operations as itinerant.

1.2. Literature review on GA demand models

GA demand models can be classified into two categories. Models in the first category focus on studying the macro-level relationship between GA demand and demand determinants (e.g., social-economic factors). Ratchford (1974) developed a theoretical model for measuring the quantity and price of the service flow obtained from a durable good. It is concluded that the GA service quantity is sensitive to income and GA price changes. Vahovich

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http://dx.doi.org/10.1016/j.jairtraman.2014.07.003
0969-6997/

(1978) also found that income and aircraft operating cost have a significant impact on the number of hours flown by individual owners (vs. companies). Archibald and Reece (1977) used a hedonic price equation (i.e., a semi-logarithmic function) to model the relationship between aircraft characteristics and price index. Their results support the hypothesis that the demand for fuel efficiency increases if there is an energy crisis (e.g., oil embargo). Li and Trani (2013) showed that the relative fuel price - fuel price compared with disposable income per capita −is a significant determinant of the utilization of piston engine aircraft. In addition, their results suggest that the elasticity of the utilization rate with respect to the relative fuel price is about −0.6.

To effectively allocate limited resources among the diverse network of airports in the U.S. requires GA demand forecasts at county or airport level. However, models in the first category usually lack the capability to provide county or airport-level demand forecasts. From this point of view, models in the second category are more important because they are developed to model the microscopic relationship between county or airport-level GA demand and local demand determinants. Baxter and Philip Howrey (1968) investigated the determinants of county-level GA operations. Their study shows that population, personal income, agriculture employment, number of airports and airport quality (e.g., the fraction of airports with runway lights and paved runway) could be significant determinants. Wingrove et al. (2002) developed a top-down approach to forecast GA fleet and itinerant GA operations at an airport. The significant demand determinants they identified are similar to those reported by Baxter and Philip Howrey (1968). Ghobrial and Ramdass (1993), Wingrove et al., (2002) developed an econometric model to forecast demand at GA airports. Ghobrial (1997) further extended the model by enhancing the model's structure and using a larger sample of GA airports for model calibration. In particular, their results show that supply factors (e.g., control tower and runway) are significant determinants of flight operations. Hoekstra (2000) used a linear model to forecast the GA operation at small towered and non-towered airports. He found that the number of based aircraft at an airport, income per capita, and whether the airport is certificated for commercial services are among the important demand determinants. GRA (2001b) refined Hoekstra's model by considering more local variables (e.g. presence of a flight school at the airport) and more data in model calibration. Dou et al. (2001) also developed a linear model to forecast GA demand by using local social-economic and demographic factors. However, their model has a low goodness of fit (i.e., low R-square). Baik et al. (2006), Dou et al. (2001) utilized gravity models to study the distribution of GA demand among airports. Both of their models show that the distance between airports is a particularly important factor for the distribution of GA demand.

The model presented in this paper can be considered an extension of the econometric model developed by Ghobrial (1997). Our study departs from the previous one in the following three aspects:

1) The focus of the study in Ghobrial (1997) is the aviation demand (i.e., the combination of commercial aviation and GA demand) at GA airports, while the focus of our study is the GA demand at any airport. In Ghobrial (1997), itinerant operations and local operations are combined and modeled together (i.e., by one model). In our study, itinerant GA operations and local GA operations are modeled separately (by two different models). This means our study provides a more detailed GA demand forecast.
2) The impact of fuel price is considered in the modeling. It is well known that the GA demand in the U.S. has been declining over the past decade. This decline in GA activities cannot be completely explained by the country's economic conditions. The FAA believes that the decline is partially due to the high fuel price (FAA, 2010a). The historical trend of GA fuel prices supports FAA's belief. From 2000 to 2011, the price [1] of Jet-A fuel increased by about 120%. In 2000, the cost of purchasing 1000 gallons of Jet-A fuel accounted for about 8.5% of the personal income per capita; however, this number increased to about 13.7% in 2011. The survey conducted by (Kamala et al., 2012) also supports this belief. In the survey, more than half of the responses indicated that costs were a significant reason for why they did not fly. However, to the authors' best knowledge, the effect of fuel price is not considered in the existing airport-level demand forecasting models. From this point of view, it is questionable that those models could adequately capture the impact of fuel price in their forecasts. In commercial aviation and many other modes of transportation, fuel price has been studied as an independent factor, and its impact on travel demand and travel cost has been proved to be significant. For example, in the area of mass transit/transportation, the study in Maghelal (2011) shows that fuel prices could significantly impact the U.S. transit ridership. The statistical model suggests that an additional one dollar increase to the average fuel cost could result in an increase in transit trips by 484%. Macharis et al. (2010) used a GIS-based model to investigate the impact of fuel price on the competition between intermodal transport (e.g., rail and barge) and unimodal transport (e.g., road). They found that demand shifts to intermodal transport if the fuel price increases. In the area of personal vehicles, Gallo (2011) found that a 22% increase in fuel price corresponds to a 2.56% decrease in demand for car use in Italy. Using data collected from 18 countries, Clerides and Zachariadis (2008) found that the short-term elasticity of new car fuel consumption ranges from −0.08 to −0.21, and the long-term elasticity ranges from −0.14 to −0.63. In the area of commercial air transportation, Wei and Hansen (2003) used a translog model to study the operating cost of large commercial passenger jets. They showed that fuel cost is a significant part of operating cost. Their preferred model suggests that at the sample mean a 10% increase in the fuel cost could lead to a 2.4% increase in the operating cost. Further, Ryerson and Hansen (2011) used a more advanced translog model to study the impact of fuel cost on the operating cost of commercial aircraft. They concluded that at the sample mean a 10% increase in the fuel cost would increase the operating cost by about 4%. Ryerson and Hansen (2010) adopted the Leontief technology model to investigate the potential of turboprop aircraft in reducing the fuel consumption. Their model suggests that as fuel prices increase the turboprop offers a lower operating cost per seat over a wider range of distances than the jet aircraft does.
3) In addition, more statistical criteria are considered in the selection of the explanatory variables. The models are calibrated with more comprehensive data sets. This makes our results more representative. Furthermore, we compared our model projections with those provided in the Terminal Area Forecast (TAF). The comparison shows that, under the "business-as-usual" fuel price scenario, our projections of the total demand at the towered airports are within the acceptable error range (i.e., 10%) specified by the FAA.

The rest of the paper is organized as follows: in Section 2, we introduced the TAF. In Section 3, we presented our model and the potential determinants of airport-level GA demand. In Section 4, we

[1] Statistics is obtained from Aviation Research Group/US (ARG/US) Fuel Price Survey.